

VOLUME 4 ISSUE 2 SUMMER 2010

Rendezvous

Where today meets tomorrow



Launching Into History

T&R Progress Report:

An overview of this summer's transition and retirement activities across NASA.

Moving Forward:

Building the next era in spaceflight – CCDev

Space Shuttle Endgame:

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TRANSITION & Retirement

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Pictured Above: Morning breaks over Launch Pad 39A at NASA's Kennedy Space Center as space shuttle Atlantis arrives after its 3.4 mile trip from the Vehicle Assembly Building on April 21.

From Leadership

In the position we're in today, looking at only two more scheduled missions in November and early next year, it would be wrong to imply or pretend that it's business as usual in the shuttle world. Indeed, it is not. Our program is going away and many of us will go with it. That's a fact that simply cannot be ignored, and it's getting more and more difficult to put a genuinely positive spin on it.

But we are not alone. Earlier this year, our president announced his new budget and laid out a new direction for NASA — one that likely spells the end of the Constellation Program, too. After looking at and preparing for the retirement of our program for the past six years, we can say to our Constellation brethren that we know what you're experiencing. We understand it. We're dealing with it, too.

Over the past few months, we've witnessed more and more final activities. The last motor test. The last flight-bound external tank roll-out. Many of our colleagues and friends in our extended contractor family already know when to expect their pink slips. And many of us have wondered, "Is this the last of human spaceflight for our nation?"

President Obama has assured us that he has no intention of quashing the nation's space exploration dream. He's changing the playing field and rewriting the rules of the game. In business parlance, this is known as a paradigm shift, and what that means is changing the way we look at doing our work, understanding our role in it and doing it better for even more beneficial results. The president has set new goals for American space exploration.

Of course, that doesn't necessarily help us feel better about where we are right now. But here are a couple of things that should help.

First, we've just wrapped up one of the most impressive high flight periods in the history of the shuttle program, during which we set records left and right for hardware delivery, flight processing and lowest number of in-flight anomalies, among other achievements. The last time more than seven missions were launched in a 12-month period was in 1997 and back then, the shuttle work force was almost a third larger than it is today.

Second, shuttle knowledge capture or knowledge management mean different things to different groups, but one thing is for certain. There is an active effort to capture, retain and protect as much shuttle knowledge as possible for use in future programs or for posterity. A record of our entire program in all its glorious detail will live at the U.S. Library of Congress. Our program will live on in the history pages while new programs will fill the science pages.

And finally, in the last couple of weeks, tests have been successfully completed that achieve pivotal milestones in proof of concept for the next immediate phase of space operations — the Commercial Orbital Transportation

From Leadership

Services, Cargo Resupply Services and Crew and Cargo Development under the direction of NASA's Commercial Crew and Cargo Program office. America will not stop flying human space missions.

Right now, the best thing we can do to ensure the future is do our jobs and do them well. Just like we always have. As I've said in this space before, there is no better-qualified, more experienced spaceflight work force than our space shuttle and International Space Station work force. No one in the world can do what we do or what we've already done.

We are the torchbearers for the future of human spaceflight. And that's something we should all celebrate.



Dorothy Rasco
Manager, Space Shuttle Business Office
SSP T&R Lead
Johnson Space Center

From the Editor

As our much loved shuttle program winds down, the images that remind us of how truly magnificent our achievements have been over the past three decades become even more valuable, more historical and more cherished. The shuttle, with its larger-than-life infrastructure, is iconic. And it represents the very best attributes of humankind — our ability to think beyond the boundaries of everyday life, envision castles (or space stations) in the sky and achieve the impossible through ingenuity, intelligence and determination.

For this issue of *Rendezvous*, while discussing more retirement issues than transition issues as we edge closer to the end of the program, we chose images for our cover and title pages that capture the power, technological sophistication, beauty and drama of the program we're getting ready to retire.

On our cover, the photograph of Atlantis on the pad prior to the launch of the STS-132 mission is an image that is familiar to the folks at Kennedy Space Center. But to much of the shuttle work force in other centers, the stack viewed from this angle beneath the rotating service structure underscores both the complexity of pre-launch activities and launch pad operations.

For T&R Progress Report, we chose a launch image, just not a shuttle launch. SpaceX's unmanned Falcon 9 was the largest privately funded rocket and space capsule ever to reach orbit. As a space-faring community, we look forward to seeing many more of these launches in the next several years as the COTS program moves into full flight operations.

In the wake of President Obama's budget revision, submitted in late June, we thought it important to explain what it means in regards to center assignments going forward. For this article, we chose a stunning image from the past. Who can ever forget the pivotal role Stennis Space Center has played in propulsion testing through the ages?

For our article about the proof-of-concept phase of CCDev, we relied on artists' renderings to give us an idea what the future of spaceflight will look like. Whether the concept that moves from science fiction to space fact is Sierra Nevada's Dream Chaser or Boeing's 7-person crew capsule, or possibly both, is yet to be determined. But speaking for a community that would rather not be earth-bound, we certainly can't wait to find out.

The image we chose for our article about the efforts of the Space Shuttle Transition Liaison Office focuses attention on where the money comes from — not just for space operations and exploration, but also for the communities impacted by changes in our space policy and our marching orders. NASA is, after all, a federal agency.

We hope you'll find these images as inspiring as we have. There is an intangible beauty to the very nature of spaceflight that often leaves even the most eloquent tongue-tied. But if there's one thought we should all share when we look at these amazing images, it's this:

"Wow. We did that."

Progress Report Activities Across NASA

T&R

An overview of this summer's transition and retirement activities across NASA.

All in a Successful Year's Work

Despite independent studies showing NASA had less than a 20 percent likelihood of achieving a successful high flight rate, there were seven successful space shuttle flights in the year from May 11, 2009, to May 14, 2010. That does not include the successful launch of STS-119 in March of 2009. Overall, NASA has launched eight flights in 14 months.

All in a Successful Year's Work

SpaceX Aims to Advance Space Exploration

The Last Flight-bound ET

Extended Flight Schedule for Shuttle

Orion Pad Abort-1 Test – A Textbook Launch

Revitalizing NASA Communities

Sub-Scale Rocket Motor Test is Successful

Work Continues at E-1 Stand

Pictured above: SpaceX's unmanned Falcon 9 rocket lifts off from Kennedy Space Center on June 4.

Throughout this high flight rate period, shuttle processing has set and reset records for the lowest number of interim problem reports during processing. Multiple projects and integration teams are responsible for new records for the lowest number of debris releases and the lowest number of thermal protection system damages on the orbiter. Not to mention, all of the projects have set records for the lowest number of in-flight anomalies.

These accomplishments are due to many different contractor and government organizations working as a team. But what makes this feat even more amazing is that it was achieved while necessarily reducing the total work force by 32 percent, from 14,577 in 2005 to 9,878 today, the lowest in program history.

SpaceX Aims to Advance Space Exploration

The launch of SpaceX's unmanned Falcon 9 from Kennedy Space Center on June 4 (pictured above) will certainly go down in the history books. It will also provide a needed boost to a young commercial space industry that its proponents say will soon become a multibillion-dollar business.

SpaceX broke its own record on June 4 by successfully launching the largest privately funded rocket and space capsule to ever reach orbit. The previous record was set when the company launched its smaller, first-generation Falcon 1 rocket in 2008.

It wasn't all smooth sailing. There were a few bumps when Cape Canaveral officials had to delay the launch count for more than 90 minutes. Then, after the launch sequence was restarted, questionable readings in the engine ignition system caused them to abort with two seconds remaining. Just fifteen minutes before the launch window was to close, the Falcon 9 blasted off on its maiden voyage. As planned, the Falcon 9 rocket achieved orbit nine minutes into the flight, drawing praise from NASA, the White House and everyone eager for the company to start resupplying the International Space Station.

SpaceX has a manifest of more than 30 contracted missions, which includes delivering commercial satellites to orbit as well as carrying NASA cargo to and from the space station. The Falcon 9 rocket and Dragon spacecraft are designed to meet NASA's published human rating standards for the transportation of astronauts, and SpaceX is hoping to transition quickly to delivering astronauts to the space station. One crucial item to be completed before reaching that milestone is the development and testing of the launch escape system.

The NASA Commercial Orbital Transportation Services (COTS) program is demonstrating the advantages of combining private sector responsiveness and ingenuity with the guidance, insight and support of the U.S. government. SpaceX has developed all the flight hardware for the Falcon 9 orbital rocket and Dragon spacecraft, as well as three launch sites. The company currently employs more than 1,000 workers in California, Florida and Texas, and expects to grow significantly in the next couple of years with the majority of growth to occur in Florida and Texas.

"This is a major milestone not only for SpaceX, but the increasingly bright future of spaceflight," Elon Musk, Chief Executive Officer and Chief Technology Officer of SpaceX, said in a company press release. "It was an incredible day for the employees of SpaceX, but it is important to note that we did not do this alone. I'd like to thank from the bottom of my heart all of our supporters in NASA – particularly the Commercial Orbital Transportation Services office – the U.S. Air Force, the FAA and our customers. Their support has been critical to this success."



SpaceX's Falcon 9 rocket during a launch pad test in Florida on March 13. Source: SpaceX.

The Last Flight-bound ET

NASA and Lockheed Martin Space Systems Company held a ceremony at NASA's Michoud Assembly Facility in New Orleans on July 8, to commemorate the rollout of the final external tank for the last space shuttle flight and celebrate 37 years of successful tank deliveries. The last external tank scheduled



An aerial view of space shuttle external tank ET-138 as it rolls out at Michoud Assembly Facility near New Orleans, La., followed by its team.

to fly on a shuttle mission, designated ET-138, was completed on June 25 by Lockheed Martin workers at Michoud.

Hundreds of employees, many of whom have been there for the entire 37 years of the program, gathered around to watch the tank travel one mile on a wheeled transporter to the Michoud barge dock. In typical New Orleans style, the Storyville Stompers, a traditional area brass band, also accompanied the tank, playing tunes while the crowd waved farewell to ET-138 as it prepared to travel 900 miles by sea to NASA's Kennedy Space Center. Once it arrives, it will be attached to space shuttle Endeavour and solid rocket boosters for mission STS-134. STS-134 is scheduled to launch February 26, 2011.

Michoud Space Systems workers have delivered 135 flight tanks to NASA during the 29 years of flying the space shuttle. Work will be completed on one additional external tank, ET-122, which was damaged by falling debris during Hurricane Katrina in August 2005. It is being restored to flight configuration and will serve as the "launch on need" tank, if necessary.



Mission patches for the upcoming STS-133 and STS-134 missions.

Extended Flight Schedule for Space Shuttle Program

The launch dates for space shuttle Discovery's STS-133 mission and space shuttle Endeavor's STS-134 flight have changed.

Space shuttle Discovery is scheduled to launch Nov. 1, at 4:33 p.m. EDT. Discovery's 11-day mission is to deliver Express Logistics Carrier 4 and critical spare components, as well as the Permanent Multipurpose Module (PMM) to the International Space Station. The PMM is the modified Leonardo multi-purpose logistics module that will be left aboard the station to provide additional storage. This will be the 35th shuttle mission to the station.

The target launch date for space shuttle Endeavor is Feb. 26, at 4:19 p.m. EST. The mission is scheduled to be a 10-day round trip to deliver Express Logistics Carrier 3 and the Alpha Magnetic Spectrometer to the space station. The mission will also deliver spare parts, including two S-band communications antennas, a high-pressure gas tank, and additional spare parts for Dextre, a two-armed robot that is capable of handling delicate assembly tasks and micrometeoroid debris shields. This will be the 36th shuttle mission to the station, as well as the 134th and final scheduled shuttle flight.

Orion Pad Abort-1 Test — A Textbook Launch

In a testament to the commitment and focus of its team, the flight test of the Orion Launch Abort System at the U.S. Army's White Sands Missile Range near Las Cruces, N.M., went off flawlessly.

"Through hard work and incredible dedication over the past several years, the Orion Pad Abort-1 team has successfully tested the first U.S.-designed abort system since Apollo," said Doug Cooke, associate administrator for the Exploration Systems Mission Directorate at NASA Headquarters in Washington.

The 500,000-pound thrust abort motor rocketed away from the launch pad exactly on schedule on May 6. From launch until its touchdown about a mile north of the launch pad, the flight lasted approximately 135 seconds.

The success of the test indicated that all systems for steering, separation, stabilization, parachute deployment and landing worked perfectly. The information gathered from the test will help refine design and analysis for future launch abort systems, resulting in safer and more reliable crew escape capability during rocket launch emergencies.

"This system is much more advanced in capability and technology than any abort system designed in the past," said Cooke. "NASA strives to make human spaceflight as safe as possible, and what we learned here today will greatly contribute to that goal."

The test involved three motors: an abort motor, an altitude control motor and a jettison motor. The abort motor produced a momentary half-million pounds of thrust to propel the crew module away from the pad. With its help, the crew module reached a speed of about 445 mph within three seconds – with a maximum velocity of 539 mph – on its path to a point 1.2 miles up.

The attitude control motor fired simultaneously, steering the vehicle with eight thrusters producing as much as 7,000 pounds of thrust. It provided adjustable thrust to keep the crew module on a controlled



A crowd of onlookers watched as Pad Abort-1 took its first fully integrated flight test as White Sands Missile Range in New Mexico on May 6, 2010.



Pad Abort-1 Crew Module post-landing scene was captured by an aerial source on May 6 at the White Sands Missile Range in New Mexico.

flight path and reorient the vehicle as the abort system burned out. The jettison motor pulled the entire launch abort system away from the crew module, clearing the way for parachute deployment and landing. The three main parachutes then lowered the crew module to touch down at 16.2 mph, about one mile from the launch pad.

The successful flight test demonstrated cutting-edge, solid rocket motor technology that promises to be useful on many different launch vehicle systems, according to Stephen Gaddis, deputy launch abort system manager at Marshall Space Flight Center in Huntsville, Ala. The Orion project office at Johnson Space Center in Houston led the launch abort system test team. Langley Research Center in Hampton, Va., in partnership with Marshall, led the system development, and Dryden Flight Research Center in California prepared the crew module for integration and led the flight test vehicle integration with Lockheed Martin, the prime contractor to NASA for Orion, at White Sands Missile Range.

Revitalizing NASA Communities

On June 18, President Obama submitted to Congress a fiscal year 2011 budget amendment that allocates up to \$100 million toward stimulating regional job creation and economic growth in the aerospace industry. These funds would be made available from the Constellation Program transition element of the agency's exploration request.

The proposed amendment would provide up to \$40 million in aid for Florida's Space Coast and a maximum of about \$60 million for other affected regions. The amendment aims to support the Obama administration's new course for human spaceflight, as well as revitalize NASA communities during this transitioning to new opportunities in the space industry. The amendment does not increase the total of the administration's fiscal year 2011 budget request.

"We're very pleased the president has asked for additional support to help the communities and workers most deeply involved in our space program," NASA Administrator Charles Bolden said. "NASA's work force is incredibly talented and dedicated. This \$100 million investment in our people is essential to spurring economic growth and job creation."

In addition to the proposed amendment, the president has established the Task Force on Space Industry Workforce and Economic Development on May 31. The task force is charged with developing, in collaboration with local stakeholders, an interagency action plan to strengthen economic development strategies along the Space Coast and affected aerospace communities in other states. Their recommendations are due to the president this month.



Before and during the test firing of NASA's 24-inch-diameter, 109-inch-long solid rocket motor at NASA's Marshall Space Flight Center in Huntsville, Ala.

Sub-Scale Rocket Motor Test is Successful

NASA is a unique customer for many types of materials that require extremely reliable systems that are, in turn, thoroughly evaluated and tested for human spaceflight programs. One small change in a part or material can have a significant impact on vehicle design, flight operations and, most importantly, safety. Finding adequate replacements involves extensive testing and qualification efforts. That's where sub-scale rocket motors come in. Testing a scaled miniature version of a rocket motor is a cost-effective way to assess new materials, processes and technologies, as well as a quicker way to evaluate performance.

A sub-scale version of a rocket motor was successfully tested at Marshall Space Flight Center on May 27. Lasting only 21 seconds, the brief firing tested the 24-inch-diameter, 109-inch-long motor made from reconfigured space shuttle test equipment. The motor's nozzle was replaced with a new design, scaled down from the Ares I first-stage

development motor. It can also be modified to accommodate different mission profiles or other vehicle sizes, including heavy-lift vehicles. The data compiled from the test will be evaluated to better understand the performance of the new nozzle configuration, materials and processes.

Work Continues at E-1 Stand for Testing Commercial Rocket Engines

Work continues on the E-1 Test Stand at Stennis Space Center as engineers have recently installed an Aerojet AJ26 rocket engine for qualification testing. The E-1 Test Stand will provide the necessary engine testing for Orbital's commercial cargo flights to the International Space Station. Stennis and Orbital Science Corporation formed a partnership last April to test the Aerojet AJ26 engines that will power Orbital's Taurus II space launch vehicles. The company is under contract with NASA through the Commercial Resupply Services Program to provide eight cargo missions to the International Space Station through 2015.

Operators at Stennis have been modifying their E-1 test facility since April 2009 to test the AJ26 engines for Orbital. Work has included construction of a 27-foot-deep flame deflector trench and installation of the AJ26 engine for testing. The next step after the installation of the engine is to perform a series of "chilldown" tests, which involve running sub-cooled rocket propellants through the engine to mimic the activity of an actual "hotfire" ignition test. The purpose of the chilldown tests is to verify proper temperature conditioning of the engine systems and time required to properly chill the engine, as well as measure the quantity of liquid oxygen required to perform the operation. Once all the necessary qualification tests are completed, the test engine will be removed from the Stennis E-1 test facility to make way for installation and testing of the actual flight engine.

The partnership between Orbital and Stennis is part of NASA's Commercial Orbital Transportation Services initiative. The Stennis rocket engine testing agreement with Orbital is an example of how NASA and commercial interests can work together to develop space travel capabilities.



Modification work continues on the E-1 Test Stand at NASA's John C. Stennis Space Center in Miss. earlier this year in preparation for testing.



Moving Forward

Commercial Crew Development Building the Next Era in Spaceflight

"We have expertise in 50 years of human spaceflight that we have agreed to share with these companies."

— Alan Lindenmoyer, Program Manager, Commercial Crew & Cargo Program Office

Human spaceflight has always been a government-industry partnership. A little known fact is that approximately 85 percent of the funds spent by NASA each year go to industry. Where would we be today without the contributions of companies such as North American/Rockwell International and McDonnell Douglas (now Boeing), Pratt & Whitney Rocketdyne, Alliant Techsystems, Lockheed Martin and United Space Alliance, to name just a few? There would have been no Mercury, Gemini or Apollo programs, much less a Space Shuttle Program or International Space Station.

Pictured above: An artist's depiction of the Dream Chaser spacecraft, Sierra Nevada's commercial space transportation system concept, approaching the International Space Station. Source: Sierra Nevada Corporation.

In our last issue of Rendezvous, we took a look at the coming milestones of the Commercial Orbital Transportation Services Project (COTS) under the purview of the Commercial Crew and Cargo Program Office and Cargo Resupply Services (CRS) development activities. In this issue, Rendezvous looks into the long-lead commercial crew capabilities currently being developed under the Commercial Crew Development agreements which were awarded last February.

Jump-starting the private sector

NASA's Commercial Crew and Cargo Program, known as C3PO, is applying American Recovery and Reinvestment Act funds to stimulate efforts within the private sector to develop and demonstrate human spaceflight capabilities. These efforts are intended to foster entrepreneurial activity leading to job growth in engineering, analysis, design and research, and to promote economic recovery as capabilities for new markets are created.

NASA's activities started with cargo, but were always intended to eventually include the capability of launching people to space. The recovery act provided NASA \$50 million for the development of commercial crew space transportation concepts and enabling capabilities, known as Commercial Crew Development or CCDev. CCDev is a yearlong effort focused on developing critical capabilities and retiring key risks as a precursor to a full-scale commercial crew transportation development effort. In other words, proof of concept.

For CCDev's "head start" efforts, NASA received 36 submissions in response to its August 2009 announcement for proposals in a wide variety of technology areas. Five Space Act Agreements were executed by NASA in early 2010.

The CCDev Five	Space Act Agreement Value
Blue Origin	\$3.7 million
Boeing	\$18 million
Paragon	\$1.4 million
Sierra Nevada	\$20 million
United Launch Alliance	\$6.7 million

According to Valin Thorn, Deputy Program Manager of C3PO, the Space Act Agreements were designed to partially fund the development of system concepts, key technologies and capabilities that could ultimately be used in commercial crew human space transportation systems. The selected teams also proposed matching funds from other sources that would leverage the taxpayer investment. But whatever other funding they get, and whatever the project ends up costing, NASA's contribution is fixed.

"Just as in the COTS projects, in the CCDev project we have fixed-price, pay-for-performance milestones," Thorn said. "There's no extra money invested by NASA if the projects cost more than projected."

This stipulation moves the cost-benefit trade to the commercial partners who are the people closest to the work.

Thorn further explained that this fixed-price milestone model creates a self-regulating development effort that's cost effective because the development partners are likely to be more prudent about how and where they invest their own dollars. But that doesn't mean NASA relinquishes all responsibility, especially in the area of safety.

"Of course, we will be even more closely engaged with commercial crew partners than we are with our COTS cargo partners, to ensure NASA human spaceflight certification is achieved and that the vehicles are safe for crew," Thorn said.

A government-industry partnership

Like the COTS agreements that preceded it, the CCDev effort was planned from the beginning to be a government-industry partnership that paved the way for a new method of doing spaceflight business with the private sector. To provide expert assistance, technical support and oversight, NASA established a Commercial Advisory Team (CAT) that comprises more than 100 agency experts in 30 technical disciplines to help advise and support each industry partner's overall development activities. For the commercial crew effort, a new insight and oversight approach will be required.

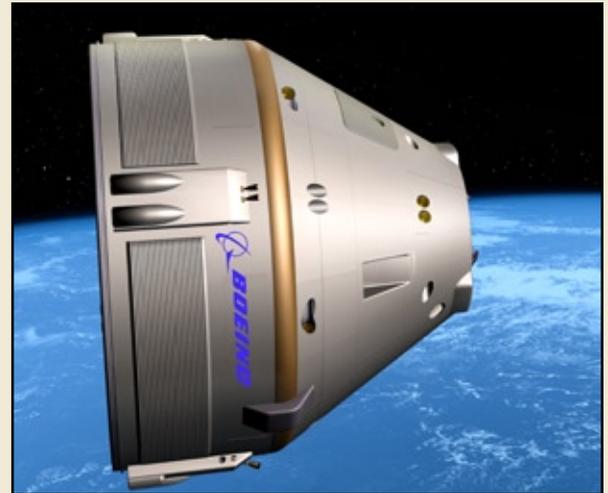
“For the full-scale commercial crew transportation system development, NASA will have a dedicated team of NASA civil servants for each commercial partner, tailored to their needs,” Thorn elaborated. “This team will provide insight and participate in development with the partners from the beginning to the end of development.”

Although NASA’s CCDev partners have different technology responsibilities and objectives, they all share similar challenges and motivations. Paramount among those challenges is the need to offset the developmental risks to make the investment more attractive to each partners’ stakeholders, whether they be shareholders, as with Boeing, or smaller enterprises, as is the case for Blue Origin and Paragon.

As NASA and all space program contractors understand, it’s not easy to raise the funds needed for space exploration development. And quite often the funds allocated don’t match up with the cost realities of design, development, testing and evaluation – much less fabrication, processing and operations once the concepts are proven. So what motivates them to participate and pursue such lofty objectives?

Thorn said that the short-term motivation for the CCDev effort is for companies to make themselves more competitive for future full-scale commercial crew development. That then feeds into the long-term goal.

“Everyone wants to play a pivotal role in the nation’s future commercial human spaceflight programs,” Thorn said.



Boeing is maturing the design of its CST-100 spacecraft, designed to carry a crew of seven. The CST will be bigger than Apollo, but smaller than Orion, and will be able to launch on a variety of rockets including Atlas, Delta and Falcon. Source: Boeing.

The right way and the right balance

Many of the CCDev companies are familiar to the space community. However, some of their roles are changing. According to Thorn, in government/industry partnerships, there are the best things for the government to do and best things for private industry to undertake. There’s always been the challenge of striking a balance that capitalizes on government’s and industry’s strengths while minimizing their weaknesses. By working with industry to develop, operate and sustain what will become routine space system operations in the future, such as space station resupply and crew transportation, NASA will be freed up to pursue the higher objective of space exploration, which is the intent of President Obama’s proposed policy and budget for NASA.

“The timing of the proposed cancellation of the Constellation Program is unfortunate because some people are assuming that this new emphasis on the commercial model for low Earth orbit operations is taking Constellation’s place,” Thorn said. “But the two programs were always complementary, meant to work together, and I think that’s becoming more clear as people study the situation.”

Thorn believes that the future for NASA and the extended human spaceflight family, including commercial partners, is quite bright indeed.

“I think we’re going to find ourselves more engaged, more challenged, more rewarded with new human spaceflight programs — both for exploration beyond Earth orbit and for low Earth orbit operations with our commercial partners,” he concluded.

Blue Origin

Blue Origin of Kent, Wash., was awarded approximately \$3.7 million for risk-mitigation activities related to development of their “pusher” Launch Escape System (LES) that will increase flight safety and lower operating costs, and to produce a composite crew module pressure vessel for structural testing that may lower their spacecraft weight and improve damage tolerance.

Boeing

The Boeing Company was awarded approximately \$18 million to develop their commercial crew space transportation system through System Definition Review. Boeing’s system concept is for a seven-crew capsule based on the Apollo shape that may be launched on a medium class expendable launch vehicle. Boeing’s effort will include capability demonstrations in their integrated reaction control system; orbital maneuvering system; launch escape system; thermal protection system; avionics integration facility; crew module pressure vessel fabrication; landing system; life support system; automated rendezvous and docking; and crew module mockup fabrication.

Paragon

Paragon Space Development Corporation of Tucson, Ariz., was awarded approximately \$1.4 million to develop an environmental control and life support air revitalization system engineering development unit.

Sierra Nevada

Sierra Nevada Corporation of Louisville, Colo., was awarded approximately \$20 million to further develop their commercial space transportation system. Sierra Nevada’s system concept is the Dream Chaser, a seven-crew spacecraft, based on NASA’s HL-20 lifting body, to be launched on an Atlas V 402 launch vehicle. Their CCDev effort will build and test a Dream Chaser engineering test article; define integrated structural loads; develop software algorithms; develop their software assurance plan; design their guidance; navigation and control system; build and fly a Dream Chaser scale model for approach and landing tests; build and test their orbital maneuvering system motor; build and test their reaction control system thruster prototype, which uses non-toxic propellant; conduct thermal protection system trades; mature integration of the Dream Chaser to the Atlas V launch vehicle; and build a DC/Atlas V 402 wind tunnel model for testing.

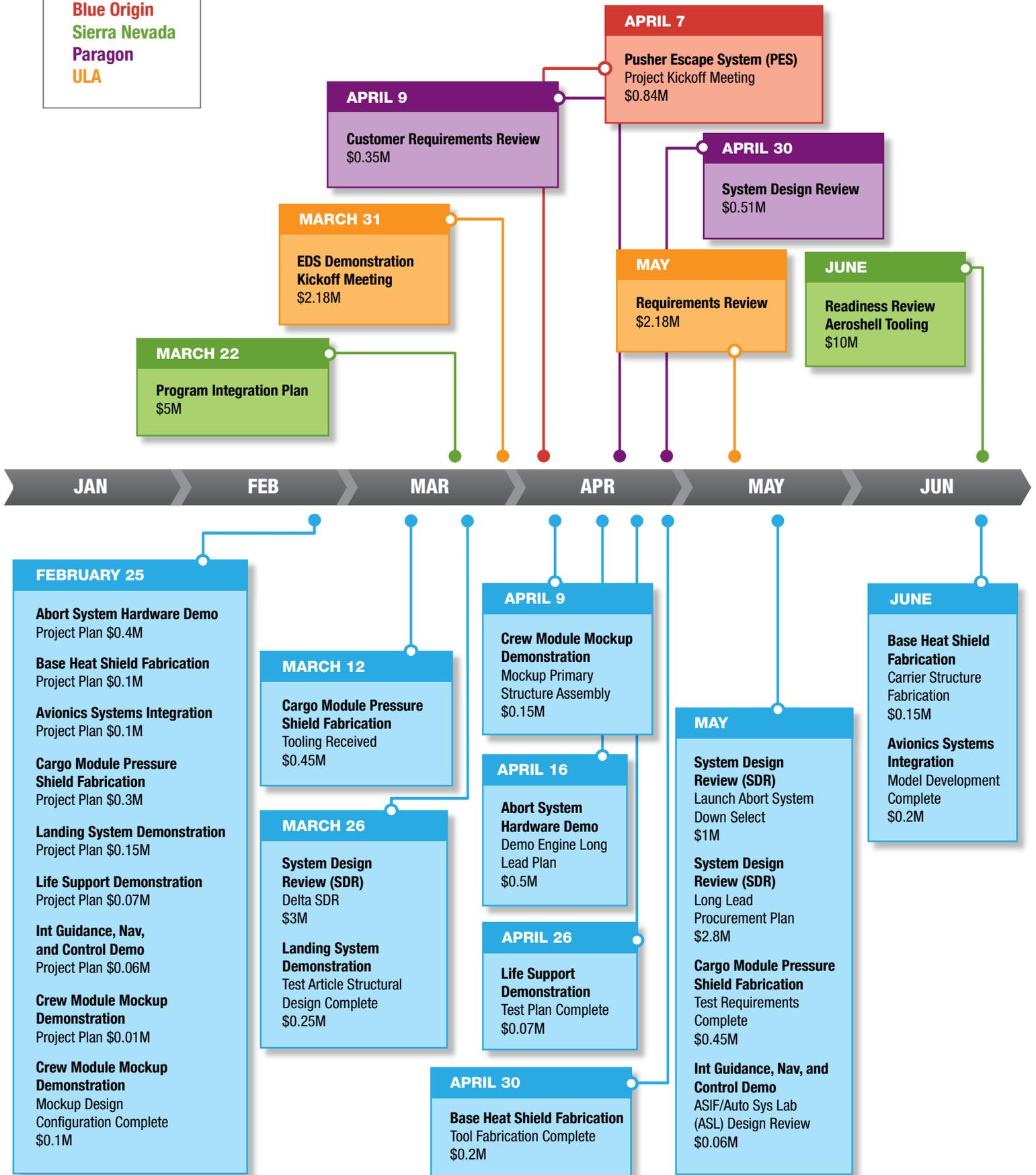
ULA

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Key

- Boeing
- Blue Origin
- Sierra Nevada
- Paragon
- ULA

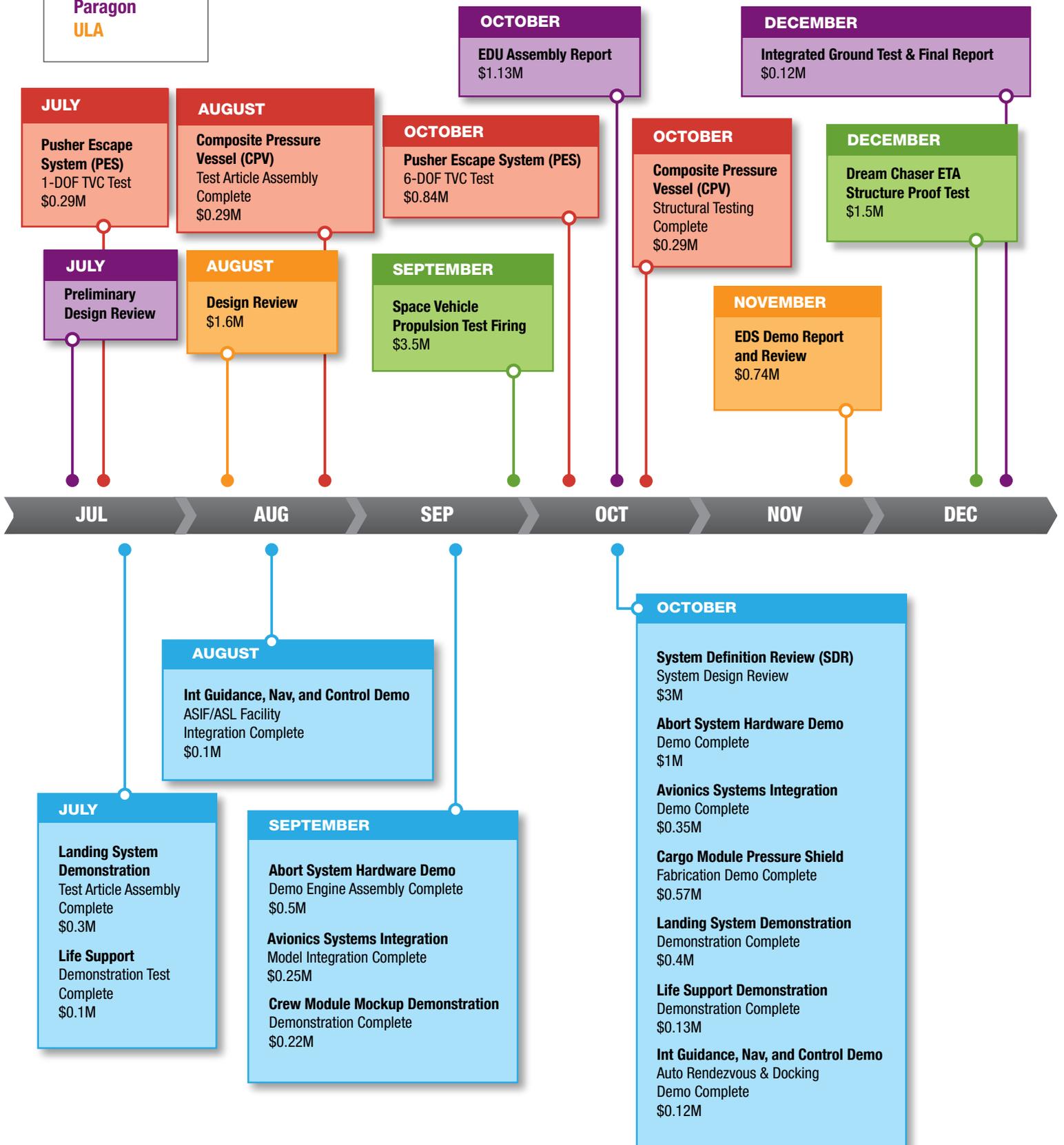
NASA-Paid CCDev Milestones 2010 Timeline: 1st & 2nd Quarters



Key

- Boeing
- Blue Origin
- Sierra Nevada
- Paragon
- ULA

NASA-Paid CCDev Milestones 2010 Timeline: 3rd & 4th Quarters



NASA Commercial Advisory Teams — COTS/CCDev

Commercial Advisory Teams were established to serve as the agency's primary points of contact and support for expert assistance and technical review of development activities.

Aerodynamics/Aerothermal

Cargo Integration

Command and Data Handling

Communications and Tracking

Electrical Power Systems

Electromagnetic Effects/Interference

Environmental Control and Life Support Systems

Environments

Extravehicular Activities

Flight Crew Operations

Flight Crew Systems

Ground/Launch Operations

Guidance, Navigation and Control

Integrated Vehicle Health Management

ISS Visiting Vehicle Integration

Materials and Processes

Micrometeoroid/Orbital Debris

Probabilistic Risk Assessments

Propulsion

Rendezvous and Proximity Operations

Safety, Reliability and Risk

Software

Space Flight Operations

Space Station Robotic Arm/Robotics

Structures and Mechanisms

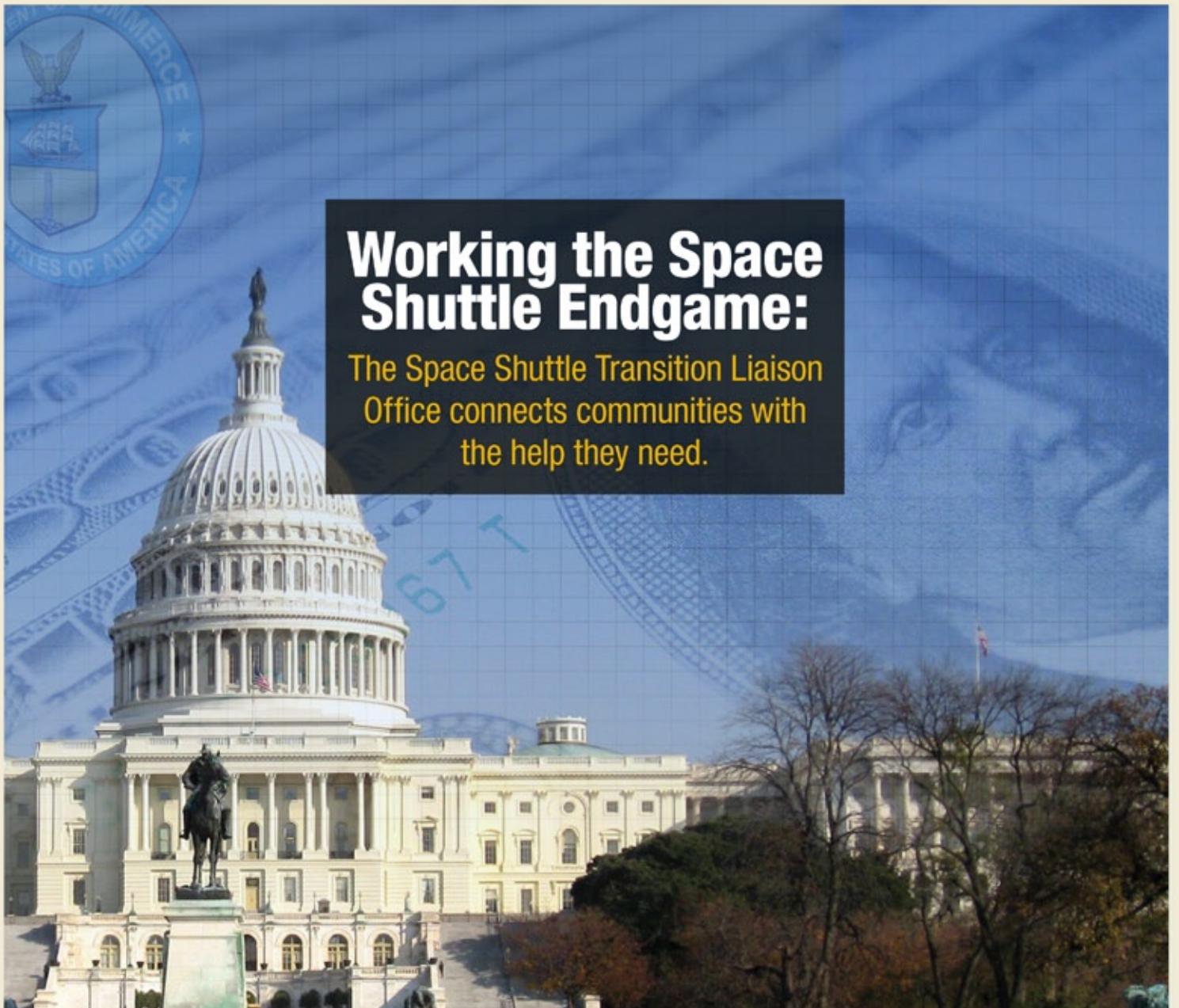
Test and Verification

Thermal Control Systems

Thermal Protection Systems

Toxicology

Training and Simulation



Working the Space Shuttle Endgame:

The Space Shuttle Transition Liaison Office connects communities with the help they need.

There are several “fronts” that demand coverage in program retirement activities and initiatives, such as the ones now on the front burner in the Space Shuttle Program. There are the front lines, where concerned workers address their job security and their futures. There are the flanks, where communities’ workforce development and resource organizations work to provide employment opportunities through solicitation of new commerce and regional industry. And then there are the behind-the-scenes activities, where government, community and industry work together to facilitate transition and help defray the impact of program closure through information and development.

This latter theater of operation is where the Space Shuttle Transition Liaison Office, or SSTLO, does its work. *Rendezvous* talked with co-leads — Sue Leibert, the shuttle program’s human capital lead, and Sherri McGee, director of the workforce management and development division in the Office of Human Capital Management at NASA Headquarters — to find out more about the virtual office and its activities.



As directed by the NASA Authorization Act of 2008, the SSTLO was established under the auspices of the Office of Human Capital Management, to serve as a clearinghouse of information and to match people with organizations so they can get as much out of the available resources as possible. In early 2009, a plan that defined and qualified the objectives and function of the office was submitted to Congress.

“Our plan outlined how we were going to connect entities in our communities with other federal agencies that might have programs that would be of use,” McGee said. “We said, ‘We’re going to do everything we can to connect these folks, exchange information and best practices and lessons learned.’”

To underscore their promise, McGee and Leibert documented many of the activities and initiatives already underway at Johnson Space Center, Kennedy Space Center, Michoud Assembly Facility and their surrounding communities.

As they described it, the Space Shuttle Transition Liaison Office (a non-funded entity) presented an opportunity for NASA centers and communities to connect with the federal departments best suited to help them with grants, shared best practices and strategies.

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Beginning in the fall of 2009, the office held periodic teleconferences between human resource people at the centers and at contractor sites. These were expanded to include representatives from state work force commissions and community organizations such as Louisiana Works, the Gulf Coast Workforce Board (Texas) and the Brevard Workforce Development Board (Florida), among others. These teleconferences were used to disseminate current news, determine needs and share information.

“Our first telecon was a ‘here’s what we know, here’s what we don’t, this is what’s going on, what do you folks need, what would be useful’ kind of thing,” Leibert said.

Because the Department of Labor handles work force issues, Leibert also met with Jane Oates, head of the department’s training and employment administration, to go over NASA’s best guess at the work force numbers for the contractors. From that meeting, the Space Shuttle Transition Liaison Office was then “hooked up” with the Department of Labor’s national rapid response team and their regional district offices.

The Department of Labor is usually contacted after a company or a major employer starts having issues and begins lay-offs, Leibert said. So to be pulled in early gave both the department and the agency the advantage of almost a year’s worth of advance planning and the opportunity to give serious consideration to questions such as: Is there a need for retraining and skills development? What are the opportunities? What are the options? Do we need national emergency grants for certain areas?

Obviously, each affected area is different. The retraining needs for shuttle personnel in Texas will not be the same as they are for Florida, Louisiana or Utah. Leibert related that after the initial “heads-up” meeting with the Department of Labor, the department’s districts contacted the states, and the states – specifically their work force commissions – contacted the local work force boards at the community level. It’s no coincidence that this is also the way the grant money flows down from the federal level.

The same contacts were made at the Department of Commerce and the Department of Defense, where Leibert and McGee talked to the Office of Economic Adjustment to borrow pertinent best practices from Base Realignment and Closures (BRACs) experiences.

The next step was to bring everyone together. In January, more than 30 representatives from the Departments of Labor, Commerce and Defense, all the affected NASA centers, work force and economic development organizations at the state and local level, major shuttle program contractors and NASA Headquarters’ Office of Human Capital participated in meetings that highlighted activities and services provided by the Departments of Labor and Commerce and the Department of Defense’s Office of Economic Adjustment. Not only did the participants gain insight into the federal agencies but, just as importantly, they heard best practices and lessons learned from others in similar situations.

The meetings proved quite timely. Just days later the critical need for increased work force communication, grant funding to pay for work force transition programs and cooperation at all levels grew exponentially after President Obama revealed his budget and plan for NASA with the proposed cancellation of the Constellation Program.

Not only did the participants gain insight into the federal agencies but, just as importantly, they heard best practices and lessons learned from others in similar situations.



Secretary Hilda Solis,
U.S. Department of Labor

“I don’t know that it helps anyone feel better about shuttle retirement, but acknowledgment of transition issues is important,” McGee said.

After all, people are faced with similar life-altering uncertainties in almost any major transition, and the industrial and military complexes have dealt with them many times.

“If there’s comfort out there, it’s the fact that the federal government is ready and able and willing to jump in and make sure that the local communities have access to the resources they need,” McGee commented.

An example of this is the recent award, announced on June 2 by Secretary Hilda Solis of the U.S. Department of Labor, of a \$15 million National Emergency Grant to the Brevard Workforce Development Board. Previously, on April 30, the Department of Labor announced a \$1.2 million grant to assist approximately 200 workers affected by layoffs at ATK Launch Systems in Corinne, Utah, in connection with the transition of the Space Shuttle and Constellation Programs. Texas has applied for a similar grant.

Proactive cooperation is key

To date, the best examples of shuttle transition program successes have come out of shuttle work forces, contractors and organizations that identified the scope of their needs early on and were proactive in addressing them. McGee said that one example of a best practice out there in the world of shuttle transition and retirement is what’s been happening in Louisiana at Michoud Assembly Facility.

“Lockheed Martin has been extremely proactive and worked hand-in-hand with NASA and the state agency, Louisiana Works,” McGee said. “They set up transition centers and made sure that people were charging their time to the transition centers, plus they’re getting great support from their work force solutions people on different types of retraining. They had some interesting ideas that have helped make it a smooth transition.”

Part of the success at Michoud can be attributed to the nature of the work performed at the site — the external fuel tank project. Last need dates

are a known quantity, and Lockheed Martin has been able to scale down the work force little by little. From an economic standpoint, this gradual downsizing of the Michoud work force is being absorbed, for the most part, by the shipbuilding and oil and gas industry in the area.

But that’s Michoud and Lockheed Martin. The situation’s not quite the same for Kennedy, Johnson, Marshall or Stennis Space Centers. How shuttle retirement is being handled and how it impacts both the civil servant and contractor work force at other centers and their communities is different. It depends largely on the function of the center, the skill set required and the supporting community.

Marshall Space Flight Center, which shares its U.S. Army post location at Redstone Arsenal with the U.S. Army Aviation and Missile Command, is already dealing with other base realignment issues. Stennis Space Center’s future post-shuttle is not too different from its present, since historically, the center has handled propulsion testing for a number of non-NASA programs. Stennis is confident of the role it will play in the future, as engine testing will be necessary regardless of what vehicle is going into space and who it belongs to. Although the work force impact numbers are considerably greater than those of Marshall and Stennis, Johnson Space Center, is situated in a more diverse industrial community that offers employment opportunities outside the space program. There is, however, a robust community around Johnson that will be indelibly affected by the close of the shuttle program and the proposed cancellation of the Constellation Program.



Michoud Assembly Facility in New Orleans, La.

How shuttle retirement is being handled and how it impacts both the civil servant and contractor work force at other centers and their communities is different. It depends largely on the function of the center, the skill set required and the supporting community.



Secretary Gary Locke,
U.S. Department of Commerce.

Of the \$100 million set aside in the president's 2011 fiscal year budget amendment (submitted on June 18) for the purpose of spurring regional economic growth and job creation in the aerospace industry, \$60 million will be directed to space program communities other than Florida. The remaining \$40 million is for the formation of the multi-agency Task Force on Space Industry Workforce and Economic Development for Florida's Space Coast. The task force recommendations, co-chaired by Gary Locke, secretary of the U.S. Department of Commerce, and Charlie Bolden, NASA administrator, are due this month.

In the meantime, procrastination and denial within the shuttle work force is pretty much a thing of the past. With the proposed cancellation of Constellation, shuttle workers who assumed that they'd be able to transition to the new program's various projects, or make the jump from civil service to contractor (or vice versa), have found themselves without proverbial parachutes. Left without a clear career path to pursue in a field that engenders devotion, the tendency is to wonder, "What do we do now?" and ask, "What can I do with my skills and training?" The sense of urgency, with less than a year left to fly, is building.

The answer is that there is help out there, but some initiative is still required.

The answer is that there is help out there, but some initiative is still required. Update and polish your résumé. Keep up with certifications. Re-train if necessary. Be ready. If NASA's new direction is to explore deeper into space while the growing commercial sector takes over low Earth orbit activities and opportunities — because industry is getting to the point where it's mature enough to do that — both groups will require expertise, knowledge and skills that are currently in place in and around our spaceflight centers.

In the view of Mike Gilroy in the office of economic adjustment at the Department of Defense, it could mean that the private sector will eventually come to where the facilities and the work forces are — Alabama, California, Florida, Louisiana, Mississippi, Maryland, New Mexico, Ohio, Texas, Virginia and the District of Columbia.

Our space program isn't going away. But it won't be business as usual, because things are changing. However, with the resources now available to our work forces and their communities, thanks to the efforts of the SSTLO and shuttle program transition offices throughout the agency, there's help out there as you navigate the future.

The SSTLO Charter

“NASA established the Space Shuttle Transition Liaison Office in 2009 to assist local communities affected by termination of the Space Shuttle Program. Specifically . . . to provide nonfinancial technical assistance to the communities and identify services available for other federal, state and local agencies to assist in mitigating impacts of the end of the space shuttle era . . . It builds on an existing network of NASA human spaceflight centers, prime shuttle contractors and work force development organizations from Florida, Louisiana, New Mexico, Texas and Utah. The Space Shuttle Transition Liaison Office staff has also developed contacts with the Departments of Labor, Defense and Commerce to explore resources available to our communities.”



Charlie Bolden, NASA Administrator
Space Industry Task Force Update
June 4, Orlando, Fla.

Borrowing a page from the BRAC handbook

Base Realignment and Closures, or BRACs, seem like bad news and politicians work hard to prevent them in their districts. No one wants to lose a naval or air force base or an army post. Fortunately, NASA is not planning to shutter any of its centers. But major program changes require large work force shifts, which have direct impacts on their communities. BRACs have similar impacts. That's why the SSTLO looked to the Department of Defense for useful lessons learned.

According to Mike Gilroy in the Department of Defense's office of economic adjustment, all the "doom and gloom" that accompanies BRAC announcements doesn't hold true more often than not. The predicted tailspins of entire areas just don't happen as a rule. Gilroy attributes this to two key factors.

"When you try to measure, the negative effects [of a BRAC] are generally overstated because it's all about statistics," he explained. "It's kind of a game that depends on what your inputs are, and since every community is different, one size doesn't fit all. It's also difficult to prove a negative."

The second reason is that the doom-sayers almost never account for the fact that tightly focused communities, like the ones that grow up around bases, will rise to the challenge, especially when survival is on the line.

"When you get folks who have a sense that they're at the end of their tether, everyone starts pulling together," Gilroy said. "I really don't think there's such a thing as an economic development problem, but there can be human dynamics problems."

When everyone's on the same page, he said, then things start to happen. Communities rewrite their futures using the tools and the skills they have in place.

Gilroy cited several examples, including one from the commercial sector. Whirlpool's acquisition of Maytag in 2006 put 9,000 people in a town of 16,000 (Newton, Iowa) out of work. But the community worked together toward a common target and the community recovered.

And in the case of Fitzsimmons Army Medical Center in Aurora, Colo., the community capitalized on the skills in place and chose to reinvent itself.

"They asked themselves, 'What do we do?' and the answer was, 'We do medical,'" Gilroy said. "So they decided to take their medical skills to the next level and form an entire life sciences cluster."

Not just hospital capabilities, but also research, medical manufacturing, etc. They had a core skill set that they decided to use as a competitive advantage.

Gilroy is convinced that this willingness to reinvent is the ultimate key to success, and that both Florida's Space Coast communities and Houston's concentration of space program skills offer tremendous opportunities.



The Bioscience Park Center in Aurora, Colo., formerly Fitzsimmons Army Medical Center.



Handling the “what ifs” at Johnson Space Center

In Houston, the Gulf Coast Workforce Board, the Houston-Galveston Area Council, the Bay Area-Houston Economic Partnership, along with the Texas Workforce Commission, are all working in cooperation with Johnson Space Center’s human resources and other groups to provide transition services for NASA and contractor employees of the Space Shuttle and Constellation programs. Through its Workforce Solutions services, the Gulf Coast Workforce Board has been actively engaged in connecting potential employers with job seekers and providing a wide array of related services including updating résumés, helping with job searches, providing workshops on rebranding oneself and interviewing for jobs, assisting with federal job applications and counseling on stress and financial management.

The Gulf Coast Workforce Board is one of 28 work force boards in Texas and it is the largest. It partners with the state’s Texas Workforce Commission and provides services at no cost. Services are funded primarily through federal tax dollars that flow back into the state to assist employers and residents with their work force and employment needs. The board operates an employer services division and 29 Workforce Solutions career offices for residents in the 13-county Houston-Galveston Gulf Coast region. Several months ago, the board established the Aerospace Transition Center at 16921 El Camino Real in the Clear Lake area of Houston to help aerospace workers who might be affected by a layoff.

“Staff at the center are well aware of the special talents and needs of these workers, and some have even worked in the industry,” said Sue Cruver, public information officer for the board. “They know where to look for jobs and how to help workers transition their skills to other industries.”

But that’s only the latest center to be opened outside the gates. The board’s employer services group has been working with aerospace contractors, who make up a significant percentage of the JSC community, for more than a year. Initially, a small transition center was set up inside the United Space Alliance offices to help their workers begin to transition to other employment opportunities. Boeing was next, followed by several other major NASA contractors. And in late spring, the new, free-standing center was established and staffed with people who are familiar with the aerospace industry and “speak the language.”

The Gulf Coast Workforce Board has established relationships with employers in different regional industries, such as energy, health care, education and other areas, so its Workforce Solutions staff is able to help people who have to rethink their lives. One of the most important tools in their kit is the Workforce Solutions website (wrksolutions.com). Key to communicating its resources, the site has a special section just for transitioning aerospace workers. Here, critical information about all transition-related activities is posted daily and can be accessed by anyone who needs to know.

David Braun, aerospace marketing manager at the Bay Area-Houston Economic Partnership, or BAHEP, said the HR principles group at Johnson Space Center has been meeting at least once a month for more than a year to address transition issues. The Preserving Aerospace Talent sub-group determined that a primary need for the on- and off-site work force was a website where workers could post resumes for area employers to review and area employers could post job opportunities. This feature is now available on the Workforce Solutions site.



The new Aerospace Transition Center in Houston is located in close proximity to Johnson Space Center and is available to all shuttle program workers, civil servants and contractors alike.

... critical information about all transition-related activities is posted daily and can be accessed by anyone who needs to know.

The HR principles group has also organized a number of resource events, work fairs and similar gatherings at the Gilruth Center at Johnson, where employees facing transition can meet with organizations ready to assist them. They have opportunities to talk to people from a wide variety of professional disciplines about the different implications of retirement, retraining, relocation, etc. Representatives from several area colleges and universities are present to provide information about their programs, including opportunities for small business development for those senior level engineers and scientists close to retirement age, who are less likely to retrain and more inclined to market their space program expertise as independent consultants.

Both Cruver and Braun emphasize the point that although all stakeholders realize that shuttle program retirement is a reality, the community at large is still dealing with a lot of “what ifs” instead of a clear idea of “what’s next.”

It’s not as if the area and its work force organizations haven’t handled major work force transitions and large layoffs before. Not too long ago, the Gulf Coast Workforce Board dealt with the fall-out from the Enron fiasco and quickly set up offices throughout the area to facilitate transition services to fast-track career options for individuals who had not only suddenly lost their jobs but, in many cases, also lost their lives’ savings. Then in 2005, they handled the influx of jobless (and homeless) Hurricane Katrina refugees who sought safety and shelter in Houston.

The biggest “what if” of all is the timing. Until just a few weeks ago, the last shuttle mission was planned for November 2010. Now that’s moved out to February 2011 and Congress is debating adding an additional flight that would push the program out even further.

“It’s hard to say when various groups will go through their termination process,” Braun admitted. “It’s not like in Louisiana [Michoud Assembly Facility] where they said ‘Here’s the production schedule for the external tank, and as the last tank rolls through the assembly plant, this group, then this group, and then this group will be laid off.’”

At Johnson the process is schedule driven and, as a result, must remain much more flexible and fluid.

Resources:

www.wrksolutions.com/employer/aerospace.html
www.workintexas.com

Aerospace Transition Center

16921 El Camino Real

Houston, Texas 77058

281-956-5678

transition@wrksolutions.com



Transitioning an entire area around Kennedy Space Center

The communities all around Kennedy Space Center and Cape Canaveral have breathed the rare air of spaceflight processing and launch and landing operations for more than 50 years. So the impact of shuttle program retirement and the proposed cancellation of Constellation stretches far beyond the center's gates.

It's not just the folks who come to work at the center's orbiter processing facilities, the vehicle assembly building, the launch complexes or any of the other facilities on site. It's not just the launch directors, the ground support equipment folks, the engineers, the rocket scientists, the "steely-eyed" missile men and women, the support people and the spaceflight operations contractors. On Florida's Space Coast, it's also all the ancillary services in the communities such as Titusville, Cocoa and Cocoa Beach, Melbourne, Rockledge, Cape Canaveral and Merritt Island that depend on space program paychecks. The local pizza place, the drycleaners, the daycare operator, the car dealership, the grocery store, all the community services — the "multipliers" — will also be affected.

So, in Florida, the work force boards and community organizations know that it's not enough to find the Kennedy workers jobs: they want to find them jobs that will keep them in the area. And they've pulled in resources from both the Department of Commerce and the Department of Labor to do just that.

The human resources staff at Kennedy has been working in concert with the Brevard Workforce Development Board. Together, they've devised a set of programs to address a host of needs from retraining to counseling.

According to Judy Blanchard, director of Industry Relations for the board, the president's budget announcement in February was the wake-up call the aerospace work force transition program had been anticipating. Up to that point, it seemed that many people had been waiting with no real sense of urgency. Within weeks of the announcement, the number of space program workers registered with the board swelled to more than 4,100, and the caseloads of its career coaches jumped from an average of 75 cases per coach to more than 700. This summer, more than 900 shuttle program employees participated in a virtual job fair, and more than 45 prospective employers, nine of which were federal agencies, participated in another on-site Kennedy job fair.

So with the first allotment of the \$15 million grant the Brevard Workforce Development Board is receiving, they will fully staff and open a new transition resource center. The center will be a one-stop shop where they'll hold seminars and workshops on change management and offer in-house education partners, financial advisors and life counselors, as well as entrepreneurship consultants. The center will be similar to the one the board currently operates on-site at Kennedy with one major difference — outside the gates, it will be accessible to former shuttle workers who no longer have badge access to NASA facilities. In addition to standing up a new center, the board has put together on-the-job training programs and opportunities such as adult work experience, in which employees are given an opportunity for skills upgrades while their wages are subsidized by the board.

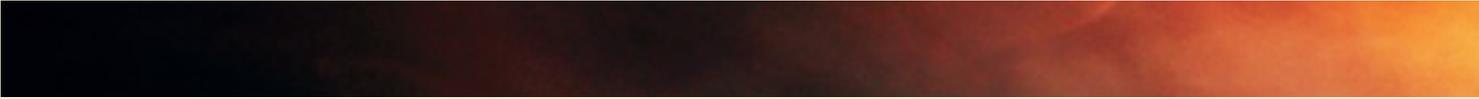
Last, but not least, the Brevard Workforce Development Board has put together a strategic outreach plan to market the area's work force capabilities throughout the region. Their specific focus will be on the emerging industries that are perceived to be the best skill set match opportunities, such as modeling and simulation, digital media, alternative energy, IT security, bio-medical, laser photonic, etc.

But in the end, it all comes down to communication.

People need a dependable place to go to find out what they need to know — a repository of information about transition resources and services, activities, opportunities, strategies and tactics. FloridaSTARnet.org is that place where anyone can go to see the latest postings on what's going on,



Judy Blanchard, director of Industry Relations, Brevard Workforce Development Board.



**Their specific focus will be on the
emerging industries that are perceived to be
the best skill set match opportunities ...**

how to get involved, who to contact, etc. A one-site-suits-all kind of place where all the regional economic development agencies, Space Florida, Enterprise Florida and the work force partners on both the civil and contractor sides of the fence can connect with the work force in transition.

Appropriately, STAR stands for Shuttle Transition Assistance and Resources.

www.floridaSTARnet.org

www.launchnewcareers.com

www.employflorida.com

www.brevardworkforce.com

www.coolspacecareers.com



WINDOW ON OUR FUTURE

An overview on spaceflight center assignments to come.

Pictured above: An archival image from 1994 shows a night test firing on the A-1 Test Stand at Stennis Space Center of a space shuttle main engine.

In the beginning there was the proposed NASA budget for fiscal year 2011. But the budget was just the beginning.

When President Obama released his budget estimate for NASA in February, it offered the space community its first look at the president's plans for the agency's future. Some things were obvious: Constellation was being canceled, the shuttle fleet was still being retired, the International Space Station's lifetime was being extended. Others were not so obvious: What's a flagship technology and where do commercial partners fit in?

Some questions are still being answered, and new questions are forming, as the Senate and House of Representatives outline their own versions of a plan for NASA. But since February, leaders across the agency have been working together to map out what NASA would look like when guided by the president's budget.

In April when center work assignments were released, employees got a glimpse of how the funds might be divvied out to their particular NASA center and how they would be used. With the addition of \$6 billion extra over five years and the creation of 13 new program offices, there was plenty of interest for every NASA center. Below is a look at some of the highlights for each of the four main human spaceflight centers. For a summary of the assignments for all NASA centers, visit www.nasa.gov/budget. Keep in mind that these all reflect the president's budget proposal. To see how that compares to the current House and Senate proposals, take a look at this presentation.

Johnson Space Center

Several existing Johnson Space Center efforts would get healthy increases under the president's budget proposal. But the new items on the assignments list are garnering the most attention at the moment, particularly the new program office to be housed at Johnson.

Flagship Technology Demonstrations program office (with deputy at Kennedy Space Center): Demonstrate transformational technologies for next-generation spaceflight capabilities. - \$424 million in FY2011 - \$6 billion over five years
Commercial Crew Development deputy program manager (with program office at Kennedy): Foster private-sector transportation to Earth orbit. - \$500 million in FY2011 - \$5.8 billion over five years
Commercial Cargo budget increase: Add new capabilities and demonstrations to the existing program and ensure commercial cargo servicing of the space station through 2020. - \$312 million in FY2011
Human Research Program budget increase: Further research on human habitation in space. - \$63 million in FY2011 - \$317 million over five years
International Space Station budget increase: Augment station functionalities, enable maximum use of the station and extend the station's life, likely to 2020 or beyond. - \$3 billion over five years
Constellation Transition funding: Transition and close out the Constellation Program. - \$1.9 billion in FY2011 - \$600 million in FY2012

Lauri Hansen has been put in charge of the planning that's being done to pave the way for the new Flagship Technology Demonstrations program office, if it does become a reality. So far, her main job has been to define what a flagship technology is and which ones are of interest to the human spaceflight program.

Though the work hasn't been easy, the definition itself is actually pretty simple, Hansen said. Flagship technologies are new technologies mature enough to be demonstrated on spaceflights. That translates to systems with a technology readiness level of about seven or higher. And fittingly enough, the Flagship Technology Demonstrations program office would be in charge of demonstrating such technologies in space.

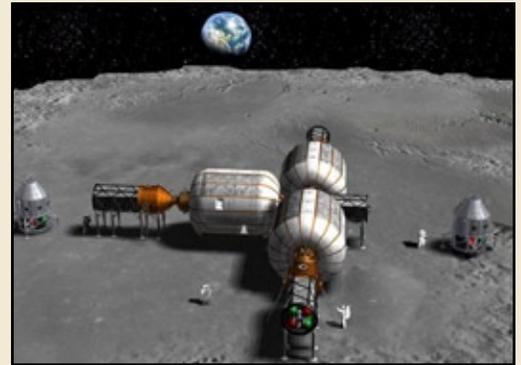
Each mission should cost \$1 billion or less, be launched in Florida on an expendable launch vehicle and have a lifecycle of five years from start to flight. Some would go to the space station, some to low Earth orbit or near-earth objects. The one thing they all have in common is that the technologies lie in the critical path for future human exploration.

Taken altogether, Hansen said it should mean a change of pace for engineers used to working on programs that last for decades, but still relates closely to the first love of just about everyone working at the human spaceflight center.

"If we're going to future destinations, we need these technologies," Hansen said. "I think that's a good fit for us. It builds on the spaceflight experience we have, leverages off a lot of our skills while still being something new. And it's cool products that you can see start and finish in five years' time."

The cool products under consideration include:

- Automated rendezvous and docking – Though this is done already by NASA's International Partners at the space station, those systems rely on TDRS and GPS systems, neither of which will be available in orbit around the moon, Mars or near-Earth objects.
- Cryogen/Propellant storage and transfer – Cryogenics boil off while spaceships wait in low Earth orbit for the right time to launch the next stage. That costs precious mass in the climb to orbit that any vehicle wanting to go far can't afford.
- Environmental control and life support systems (ECLSS)– The ECLSS loop on the station is closed to about 50 or 60 percent, and requires constant maintenance and resupply services. That's less than ideal for a mission with a two- to three-year mission to a distant destination.
- Inflatable structures – Elbow room is invaluable, no matter where you are. Inflatable structures allow you to build bigger bases without increasing your mass. They could also be used in transit to make the journey between, say, Earth and Mars more comfortable.
- Solar electric propulsion – Just because you're off planet Earth, doesn't mean it's not a good idea to go green. Using electric power for propulsion to Mars or near-Earth objects would save hundreds of thousands of pounds of propellant, allowing you to preposition logistics and infrastructure.
- Aeroassist entry, descent and landing – By making use of any atmosphere available, future vehicles would be able to land more mass at higher landing sites at destinations such as Mars. And the landing back at home would be improved as well.



An artist's depiction of an inflatable lunar habitat. Source: Bigelow.

Kennedy Space Center

The work assignments that would come out of the president's 2011 budget represent less of a change in direction for Kennedy Space Center than some might think, according to Mark Ruether, chief of Kennedy's Advance Planning Office. The 21st Century Launch Complex program office is certainly obvious enough.

Commercial Crew Development program office (with deputy at Johnson Space Center): Foster private-sector transportation services to Earth orbit. - \$500 million in FY2011 - \$5.8 billion over five years
21st Century Launch Complex program office: Modernize Kennedy's launch facilities to reduce costs for NASA and other users. - \$429 million in FY2011 - \$1.9 billion over five years
Flagship Technology Demonstrations deputy program manager (with program office at Johnson): Demonstrate transformational technologies for next-generation spaceflight capabilities. - \$429 million in FY2011 - \$6 billion over five years
Additional three months of shuttle funding: - \$600 million

"KSC has historically been the primary launch complex for NASA," Ruether said. "It makes sense for us to look at how to evolve what we currently have into what we need for the future."

And given that, the placement of the Commercial Crew Development program office logically follows. Kennedy has not only the site, but also the launch services program here, with its existing model for handling non-NASA launches. That model won't translate perfectly to handling systems meant to transport humans, rather than just cargo and equipment. But it provides a starting point to work from, and having it housed at the center



Kennedy Space Center's Vehicle Assembly Building stands tall in the sunlight. Launch Pads 39A and 39B are visible on the horizon at the center and far right.

from which the systems will actually launch ensures that the upgrades made to the launch complex match the needs identified by some of its targeted users.

[Editor's note: For an in-depth look at the Commercial Crew Development program itself, read "Building the Next Era in Spaceflight" in this issue of *Rendezvous*.]

"Before you take your first step, you want to know where you're going in subsequent steps," Ruether said.

With that in mind, the center has established a business planning office to assist the companies that partner with NASA in commercial crew activities. The office provides what Ruether called a "front door" that gives NASA partners easy access to expertise and assistance on site. And since 2006, Kennedy has also offered businesses that would benefit from close proximity, Exploration Park — a commerce site adjacent to the space center.

Kennedy's part in the flagship technology demonstrations, though not exactly old hat, isn't completely new territory, either. While most of the activity at the center thus far has been focused on shuttle processing, station assembly and launch services, there's been technology development going on there behind the scenes for some time, particularly in communication systems for analog test

activities such as the Desert RATS — or Research and Technology Studies — and In-Situ Resource Utilization programs. Still, stepping up that aspect of the center's work should open up some new doors for Kennedy workers.

"I do believe it's exciting," Ruether said. "It will be difficult — when you end a program like the shuttle program, you're going to see a significant reduction in work force. That's difficult. But if we do this right and minimize the pain during transition, I think the future is bright."

Marshall Space Flight Center

Marshall Space Flight Center's work assignments include the most new program offices of any NASA center — four of the 13 proposed across the country would be organized in Huntsville, Ala.

Heavy Lift and Propulsion Research and Development program office: Develop next-generation engines and propulsion technologies.

- \$559 million in FY2011
- \$3.1 billion over five years

Exploration Precursor Robotic program office: Scout locations for eventual human visits.

- \$105 million in FY2011
- \$2.6 billion over five years

Technology Demonstration Missions program office: Oversee flight testing of crosscutting aerospace technologies.

- \$75 million in FY2011
- \$1.4 billion over five years

Centennial Challenges program office: Manage the innovative prize program.

- \$10 million in FY2011
- \$50 million over five years

The Heavy Lift and Propulsion Research and Development program office, which has the most money attached to it, obviously falls well within Marshall's bailiwick. With the Lunar Reconnaissance Orbiter and the Lunar Crater Observing and Sensing Satellite missions under the center's belt, Exploration Precursor Robotic programs aren't unfamiliar, either. And though Marshall hasn't been responsible for its management in the past, the Centennial Challenges program isn't new.

The Technology Demonstrations Mission Program, however, is.

Technology Demonstration Missions would be the program responsible for maturing new technologies for infusion into NASA missions or other

government agencies' missions. Susan Turner, who is leading the planning activity at Marshall looking into what the office would entail, said it's a program meant to bridge the gap between low technology readiness levels and development projects.

Ion propulsion is a good example, she said. NASA's first ion engine was built in 1960, but the technology stayed in laboratories for decades before someone picked it up and was able to demonstrate it at a level that allowed it to be used on a deep space mission. It was finally incorporated into the Discovery program and flew in 2007.

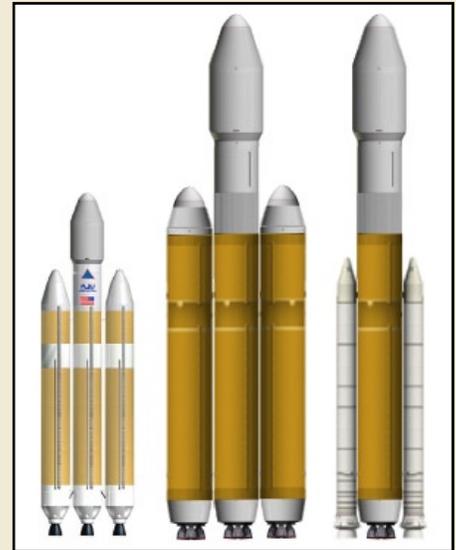
Most of the time, the problem is that new technology systems aren't mature enough to incorporate into a mission, and development itself is usually plagued by unexpected costs. The X-37 is another example. Turner managed the technology demonstrations project when it was in development, and estimates that there were probably a dozen technologies being matured for demonstration on that vehicle. Predictably the costs grew.

Such experience is what makes the office a good fit for Marshall.

"We've had hard-won lessons in maturing things," Turner said. "We have some history in developing programs, and we have an appreciation for what can happen if technology isn't sufficiently mature, and yet it's part of the development program."

The difference with the new program would be that, rather than asking other programs to take the risks of maturing a technology for its missions, the Technology Demonstration Missions program office would reduce the amount of risk involved.

The program would invest in the range of \$150 million – not a trivial amount, but much less than it would cost to incorporate a new technology into a mission – to scope out problems in the new systems and focus simply on maturing them to the point where its cost and schedule can be predicted with reasonable confidence.



An artist's depiction of heavy lift launch vehicle concepts. Source: NASA.

Stennis Space Center

Stennis Space Center has known its strengths for decades and expects to continue playing to them for decades to come.

Heavy Lift and Propulsion Technology: First and upper stage engine testing.
- \$3.1 billion over five years

Commercial Crew Development: Increase partnerships with commercial market customers, building on current engine testing planned for commercial vehicles for the Commercial Resupply Services and Commercial Orbital Transportation System programs.

"We're here for propulsion tests," said Keith Brock, Stennis' director of projects. "And there's still a role for that in the upcoming transition."

What will be changing is not the tester, but the testee. The center was already in the process of shifting from a long history of shuttle testing to preparations for the testing required for the Constellation Program. But those preparations haven't limited the center's testing capabilities – Stennis has everything it needs for liquid engine testing, whether at the component level, the system level or the stage level.

"Whatever the path forward is, we're proud to be able to use the facilities we have to develop it," Brock said. "Whether one is better than the other, that's not for us to decide – we just want to have the capability to assist in whatever the plan is."

**Whether future testing is for NASA
or a commercial company, as long as
it's liquid-fueled, Stennis is ready.**

And they do. Whether future testing is for NASA or a commercial company, as long as it's liquid-fueled, Stennis is ready.



Or almost ready – some modifications are required, depending on which propellants you’re testing. And tests can’t be done until hardware is built. Which means depending on where the path to the future leads, there could be some waiting involved.

“We’re not in control of our own destiny,” Brock said. “We’re like Kennedy in that sense. The only time we get nervous is when there’s no hardware in the system.”

Unlike Kennedy, however, Stennis has the advantage of being at the front end of the spaceflight process. Even if hardware doesn’t already exist – and in some cases it (or something similar) does – one of its first stops after it’s created will be Stennis Space Center.

Technology Readiness Levels 1 through 9: NASA Definitions

Technology Readiness Level	Description
1. Basic principles observed and reported to be translated into applied research and development.	This is the lowest "level" of technology maturation. At this level, scientific research begins to be translated into applied research and development.
2. Technology concept and/or application formulated	Once basic physical principles are observed, then at the next level of maturation, practical applications of those characteristics can be 'invented' or identified. At this level, the application is still speculative: there is not experimental proof or detailed analysis to support the conjecture.
3. Analytical and experimental critical function and/or characteristic proof of concept	At this step in the maturation process, active research and development (R&D) is initiated. This must include both analytical studies to set the technology into an appropriate context and laboratory-based studies to physically validate that the analytical predictions are correct. These studies and experiments should constitute "proof-of-concept" validation of the applications/concepts formulated at TRL 2.
4. Component and/or breadboard validation in laboratory environment	Following successful "proof-of-concept" work, basic technological elements must be integrated to establish that the "pieces" will work together to achieve concept-enabling levels of performance for a component and/or breadboard. This validation must be devised to support the concept that was formulated earlier, and should also be consistent with the requirements of potential system applications. The validation is "low-fidelity" compared to the eventual system: it could be composed of ad hoc discrete components in a laboratory.
5. Component and/or breadboard validation in relevant environment	At this level, the fidelity of the component and/or breadboard being tested has to increase significantly. The basic technological elements must be integrated with reasonably realistic supporting elements so that the total applications (component-level, sub-system level, or system-level) can be tested in a 'simulated' or somewhat realistic environment.
6. System/subsystem model or prototype demonstration in a relevant environment (ground or space)	A major step in the level of fidelity of the technology demonstration follows the completion of TRL 5. At TRL 6, a representative model or prototype system or system - which would go well beyond ad hoc, 'patch-cord' or discrete component level breadboarding - would be tested in a relevant environment. At this level, if the only 'relevant environment' is the environment of space, then the model/prototype must be demonstrated in space.
7. System prototype demonstration in a space environment	TRL 7 is a significant step beyond TRL 6, requiring an actual system prototype demonstration in a space environment. The prototype should be near or at the scale of the planned operational system and the demonstration must take place in space.
8. Actual system completed and 'flight qualified' through test and demonstration (ground or space)	In almost all cases, this level is the end of true 'system development' for most technology elements. This might include integration of new technology into an existing system. In almost all cases, the end of last 'bug fixing' aspects of true 'system development'. This might include integration of new technology into an existing system. This TRL does not include planned product improvement of ongoing or reusable systems.
9. Actual system 'flight proven' through successful mission operations	In almost all cases, the end of last 'bug fixing' aspects of true 'system development'. This might include integration of new technology into an existing system. This TRL does not include planned product improvement of ongoing or reusable systems.